Journal of Applied Mechanics

Book Reviews

Fracture Mechanics Methodology. Edited by G. C. Sih and L. Faria. Martinus Nijhoff, The Netherlands, 1984. 177 Pages. Price: $45.00.

REVIEWED BY C. H. POPELAR[1]

This book is one in the series on Engineering Application of Fracture Mechanics. The book is a product of lectures prepared for a short course on Fracture Mechanics Methodology in Lisbon from June 1–June 4, 1981. While the main emphasis of the book is the application of fracture mechanics to aircraft structures, many of the principles are applicable to other flawed members. The treatment is essentially confined to linear-elastic fracture mechanics. The fracture mechanics methodology expounded in the first two chapters (constituting over one-half of the book) is based on the strain energy density approach. The remaining chapters deal with the conventional linear-elastic fracture mechanics approach based on a critical stress intensity factor. Each of the book's five chapters is written by a different author.

In Chapter 1, R. Bodaliance treats the subject of fatigue-life predictions in metals and composites using the strain energy density approach. It is demonstrated that good agreement can be obtained between predicted and measured crack growth in metals under mixed-mode loading by integrating cycle by cycle the fatigue crack growth rate as a function of the range of the strain energy density factor deduced from constant amplitude Mode *I* tests. The fatigue life of composites is shown to correlate with a parameter based on the strain energy density modeling microcracks in the laminate matrix.

Chapter 2 by G. C. Sih contains the fundamental hypotheses and the theoretical development of the strain energy density approach. A more logical progression for those unfamiliar with this approach would have this chapter as the first one. The relationship between the strain energy density factor and the stress intensity factors of the three crack tip modes of deformation is established for small scale yielding. With such a relation the critical value of the strain energy density factor can be obtained when the Mode *I* fracture toughness is known. Several examples of the application of the approach within the confines of linear-elastic fracture mechanics are given. The use of the strain energy density in predicting ductile and fatigue crack growth is discussed. The chapter concludes with a comparison of the virtues of the strain energy density approach relative to alternative approaches to ductile fracture such as: the Irwin plastic zone correction, *J*-integral, critical strain, crack opening displacement, and resistance curve.

In Chapter 3 O. Orringer treats failures due to damage modes other than a sharp crack. This chapter contains several case studies of failures in railroad systems. Failure analysis based on spectral analysis of service load data is developed. Life prediction of structural components using linear damage rules and conventional fatigue crack growth methods are discussed.

Chapter 4 by C. M. Branco reviews the flaw acceptance method; i.e., ascertaining whether or not a detected flaw is acceptable for safe performance of a component. The British Standard PD6493 (1980) approach for determining acceptable defect levels is presented. While specifically developed for welded joints, its application to aircraft structures for stress levels below the yield strength is discussed. When significant inelastic behavior exists, the method tends to be overly conservative and an inelastic approach is required.

In Chapter 5, L. Faria reviews briefly the probabilistic approach for assessing the reliability of a structural design.

Whenever chapters of a book are authored by different individuals, there is the risk of inconsistent notation. This book is no exception. For example, *S* has been used in the first two chapters to denote the strain energy density factor whereas it denotes stress in the next two chapters and the factor of safety in the final chapter. To the authors credit, they have been careful to note the different meanings attributed to *S*. Aside from this irritant the book is well written. It is interspersed with application of fracture mechanics to the investigation of real failures. This book should be of interest to those concerned with the evaluation of the structural integrity of components.

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Incompressible Flow. By Ronald L. Panton. Wiley, New York, 1984. 780 Pages. Price $44.95.

REVIEWED BY S. A. BERGER[2]

This advanced treatment of the fundamentals of fluid dynamics is designed as a text for graduate students in

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mechanical, aerospace and civil engineering, physics, and applied mathematics, as well as a reference for professionals working in those fields. Contrary to what is suggested by the title, the book begins with a very general discussion of compressible viscous flow, so that the reader may better understand the incompressible case. Then within the context of incompressible flows, the full Reynolds number spectrum of flows is discussed, from high to vanishingly small Reynolds number. Thus extensive treatments are given *both* of boundary layers and inviscid flows. The book concludes with chapters on stability and turbulence.

Throughout is evidenced a conscious attempt to strike an even balance between the physical, mathematical, and practical engineering aspects of the subject. Particularly noteworthy to the engineering community is the heavy emphasis placed on dimensional analysis.

This is a *superb* book. I know of no book, certainly none in English, that comes close to covering as many topics or covers them as well or as comprehensively. Throughout, the discussion is very clear, and lucid, and well organized. Subtle issues concerning the basic equations and concepts are raised and addressed with great insight. Excellent physical interpretations, including molecular considerations, are given of the basic equations and each of the solutions in the book. Brief but interesting historical background and comments are also provided and enliven the text. The text is replete with uncommonly treated problems, problems that greatly enhance the theory but which are at best only mentioned in passing in other texts. Most books in this field tend to be "recipe" books; the others often are unfathomable even to the better student. This book is neither.

The treatment of mathematical preliminaries and background is particularly noteworthy and sets this book apart from others. In the text itself or in appendices there is an excellent survey of the mathematics necessary to fully understand the fluid mechanics material. This includes an early discussion of vector and tensor calculus, probably the two subjects students or readers in general are most weak in and which are most useful in understanding the material that follows. The text acknowledges the crucial and increasingly more important role numerical methods are playing in fluid mechanics by discussing such methods in detail. Finally, and again unlike any other book in the field, there is an excellent extensive treatment of asymptotic methods, including singular perturbation theory, critical to fully comprehending a topic such as boundary layer theory.

The book would be a suitable text for at least a year-long sequence of courses in fluid mechanics, and in fact there is probably enough material, with some supplementation, for courses spanning even a longer time span.

Again, this is a superb book, encyclopedic in scope, lucid in its presentation, showing throughout the efforts and talents of a brilliant teacher. It should make an excellent text, and in view of its virtues an ideal book for self-study.

Flexible Shells, Theory and Applications. Edited by E. L. Axelrad and F. A. Emmerling. Springer-Verlag, New York, 1984. 282 Pages. Price $23.00.

REVIEWED BY R. C. BENSON[3]

One of the most interesting developing fields in applied mechanics research, at least to this reviewer, is that of flexible shells. Contrasted with stiff, load-bearing shells, flexible shells not only permit large displacements, but are actually designed for that purpose. The wind-up tape measure is a commonplace example of a flexible shell. When extended, the tape measure resists bending due to its shallow cross-curvature, nevertheless, it may be collapsed without damage for storage. Historically, stiff shell applications have motivated much of the research in shell theory, and one need only look at modern aircraft to see evidence of the successes that have been achieved. By comparison, the body of literature appropriate to flexible shells is much sparser, even taking into account those works that are germane to shells both stiff and flexible. The challenge of analysis lies in the necessity of abandoning many of the kinematic assumptions that make small-deflection shell theories tractable.

The editors of *Flexible Shells* are to be commended for identifying the title subject as one meriting dedicated study, and for producing a book that is sure to become an important reference ion the field. The 17 technical papers which comprise *Flexible Shells* are drawn from the European Mechanics Colloquium 165. The purpose of the colloquium, as stated in the preface of the book, was to discuss:

"1. The formulations of the nonlinear shell theory, different in the generality of kinematic hypothesis, and in the choice of dependent variables.
2. The specialization of the shell theory for the class of shells and the respective elastic stress states assuring flexibility.
3. Possibilities to deal with the complications of the buckling analysis of flexible shells, caused by the precritical perturbations of their shape and stress state.
4. Methods of solution appropriate for the nonlinear flexible-shell problems.
5. Applications of the theory."

This précis suffices to describe the book as well as the colloquium, and the reader will find about equal attention to each topic. This, of course, is an aggressively broad list, and one should not expect that this or any single book could provide a comprehensive exposition. Where *Flexible Shells* succeeds, rather, is in providing an overview to the subject. The respective articles touch on modern developments in nonlinear shell theory, methods of analysis, and numerical solution techniques (often in regimes of multiple equilbria). There is also a nice mix of retrospection and speculation throughout the book which helps to establish the present state of knowledge in the field.

As each of the technical papers is by a different set of authors, the reader must adjust to a diversity of style. It is no impediment, however, and the editors have done a good job in organizing *Flexible Shells* so that there is a natural flow from the general to the specific. There are also a number of recurring concepts, such as Axelrad's "semimembrane theory", which help tie the book together. This is a nice addition to the flexible shell literature – argueably the first focal reference. Researchers in the field of flexible shells may not find all of their questions answered here, but there will not be a better place to start the literature search.

Elastic Stability of Circular Cylindrical Shells. By N. Yamaki. Elsevier, The Netherlands, 1984. 550 Pages. Price $57.75.

REVIEWED BY G. J. SIMITSES[4]

This book treats the subject of stability, collapse, and postbuckling behavior of elastic, isotropic, thin circular

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